United States Department of Agriculture (USDA)
Agricultural Research Service (ARS)
1420 Experiment Station Road
Watkinsville Georgia 30677 USA
Tel: 1-706-769-5631
Email: alan.franzluebbers@ars.usda.gov

Alan Franzluebbers

Ecologist

USDA

ars

Soil Carbon Sequestration

Recent Trends in Conservation Agriculture under Mediterranean Conditions

CIHEAM

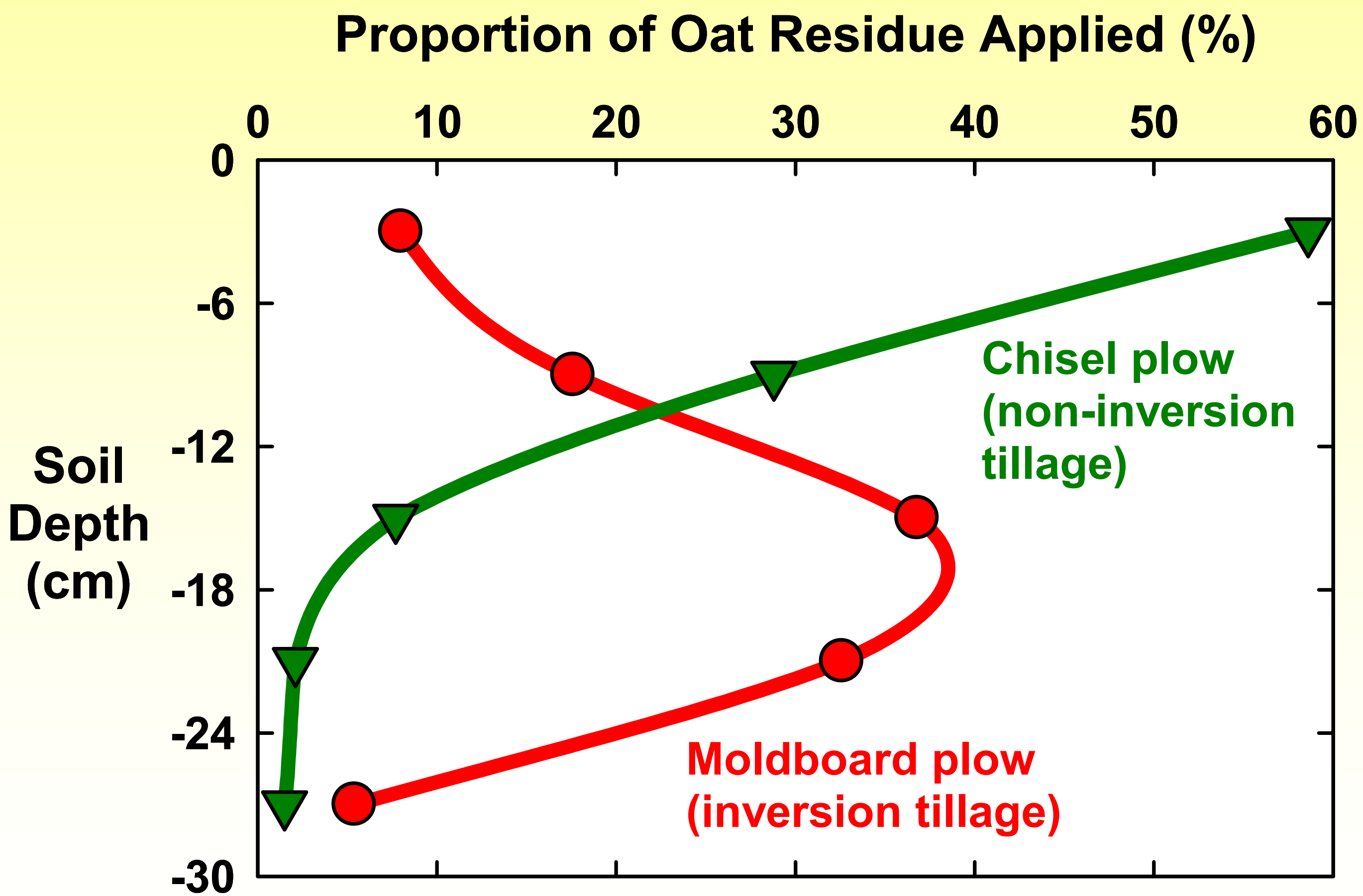
Centre International de Hautes Études Agronomiques Méditerranéennes
International Centre for Advanced Mediterranean Agronomic Studies

Soil Carbon Sequestration

- ✓ **Minimal disturbance of the soil surface is critical in avoiding soil organic matter loss from erosion and microbial decomposition**

Soil Carbon Sequestration

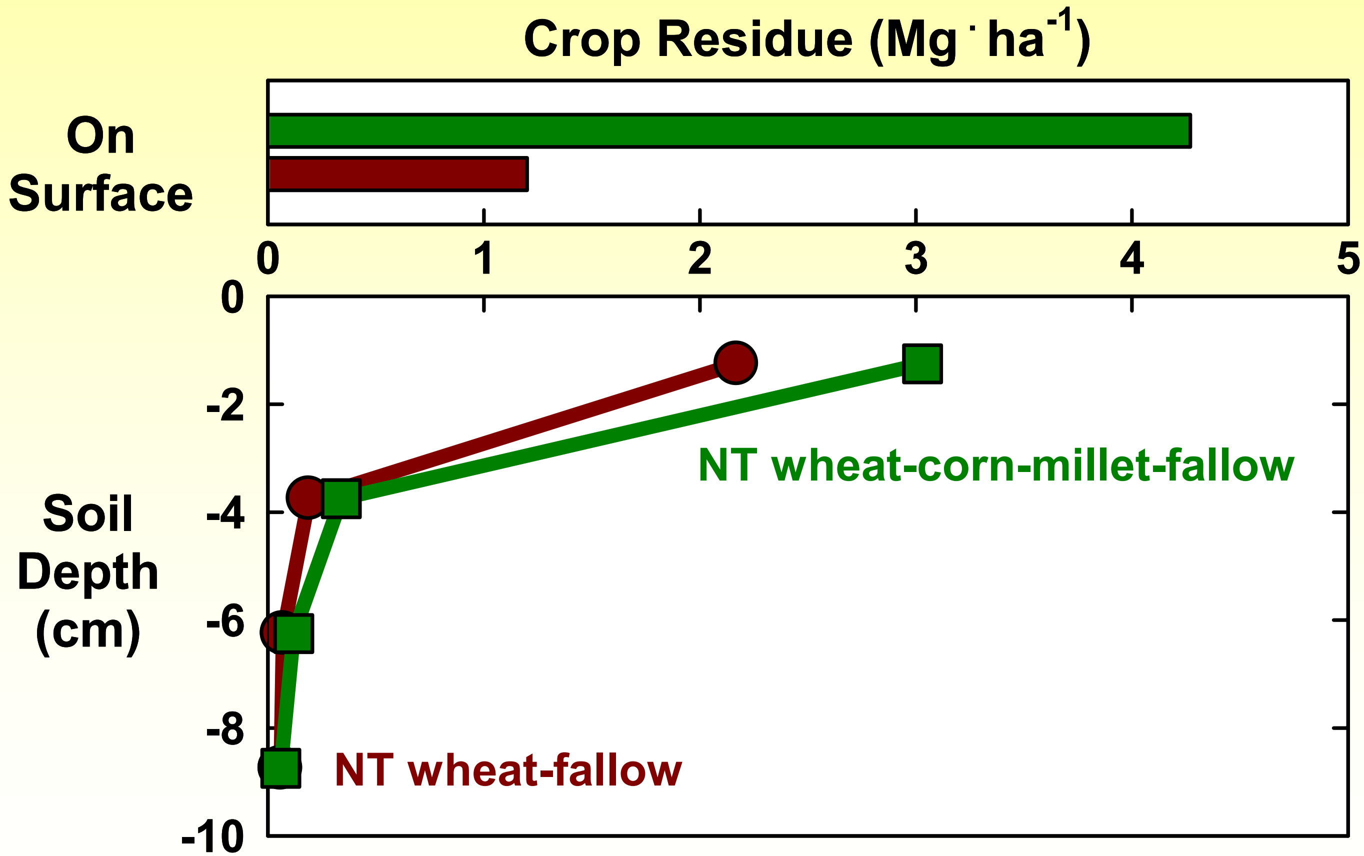
Depth distribution of crop residues



Data from Allmaras et al. (1996) Soil Sci. Soc. Am. J. 60:1209-1216

Soil Carbon Sequestration

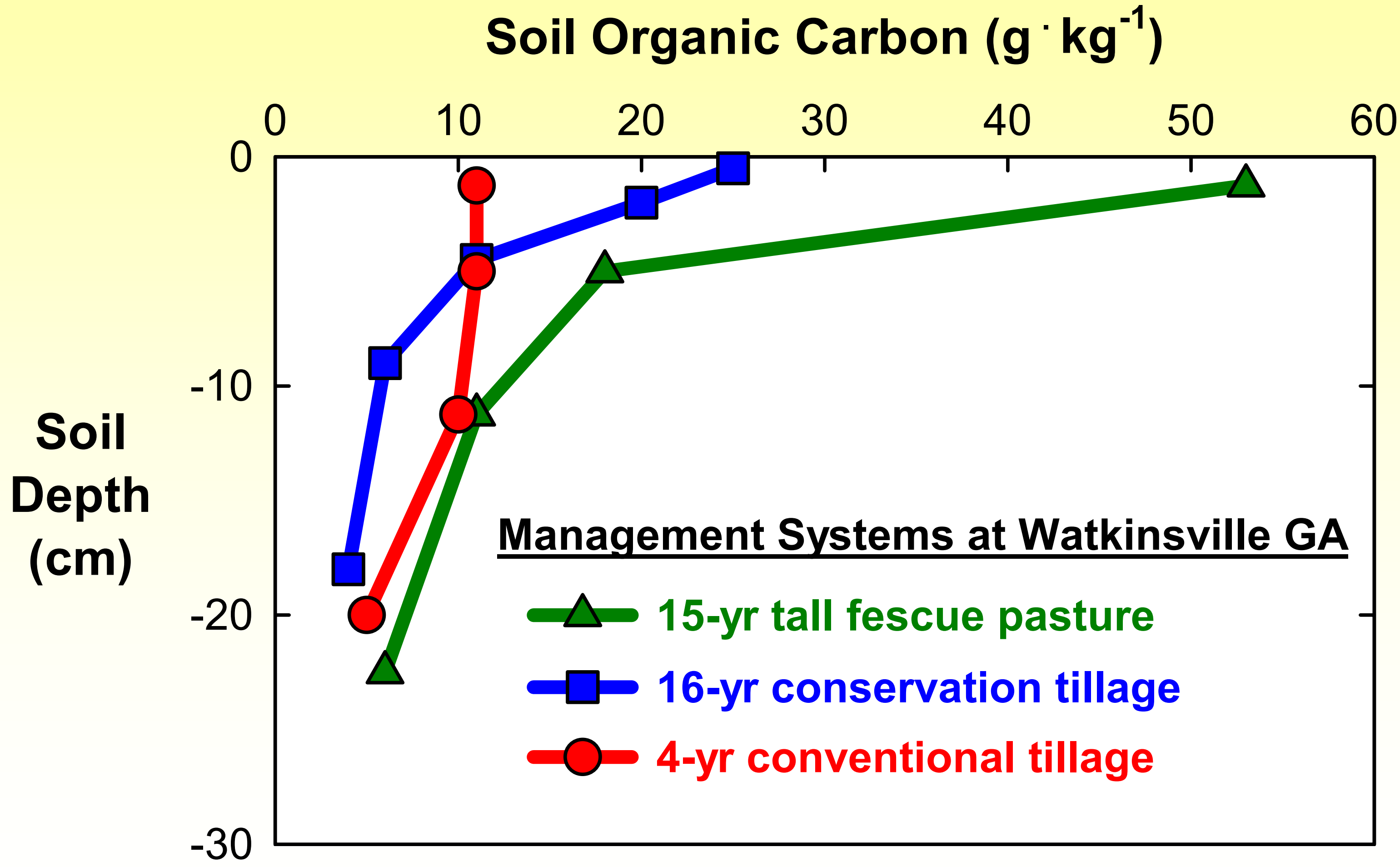
Depth distribution of crop residues



Data from Ortega et al. (2002) Agron. J. 94:944-954

Soil Carbon Sequestration

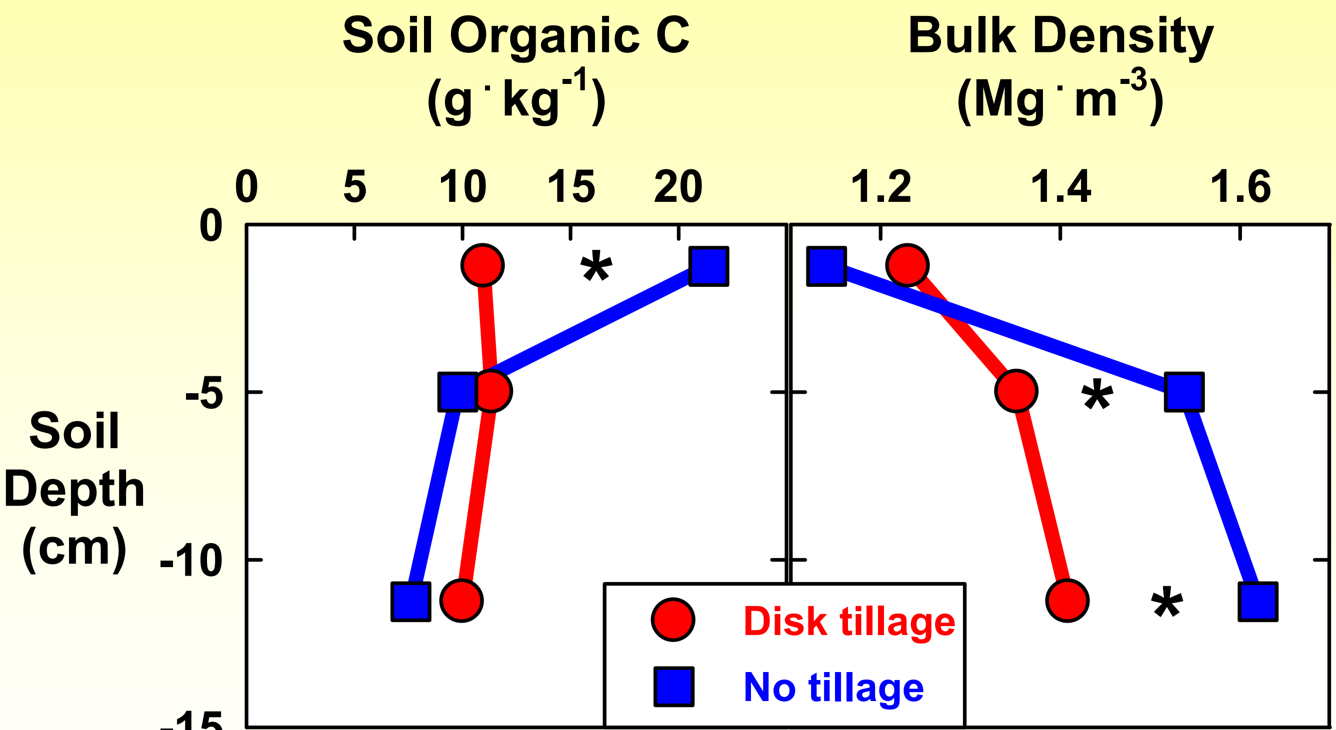
Depth distribution of soil organic C



From Schnabel et al. (2001) Ch. 12, Pot. U.S. Grazing Lands Sequester C, Lewis Publ.

Soil Carbon Sequestration

Depth distribution of soil organic C



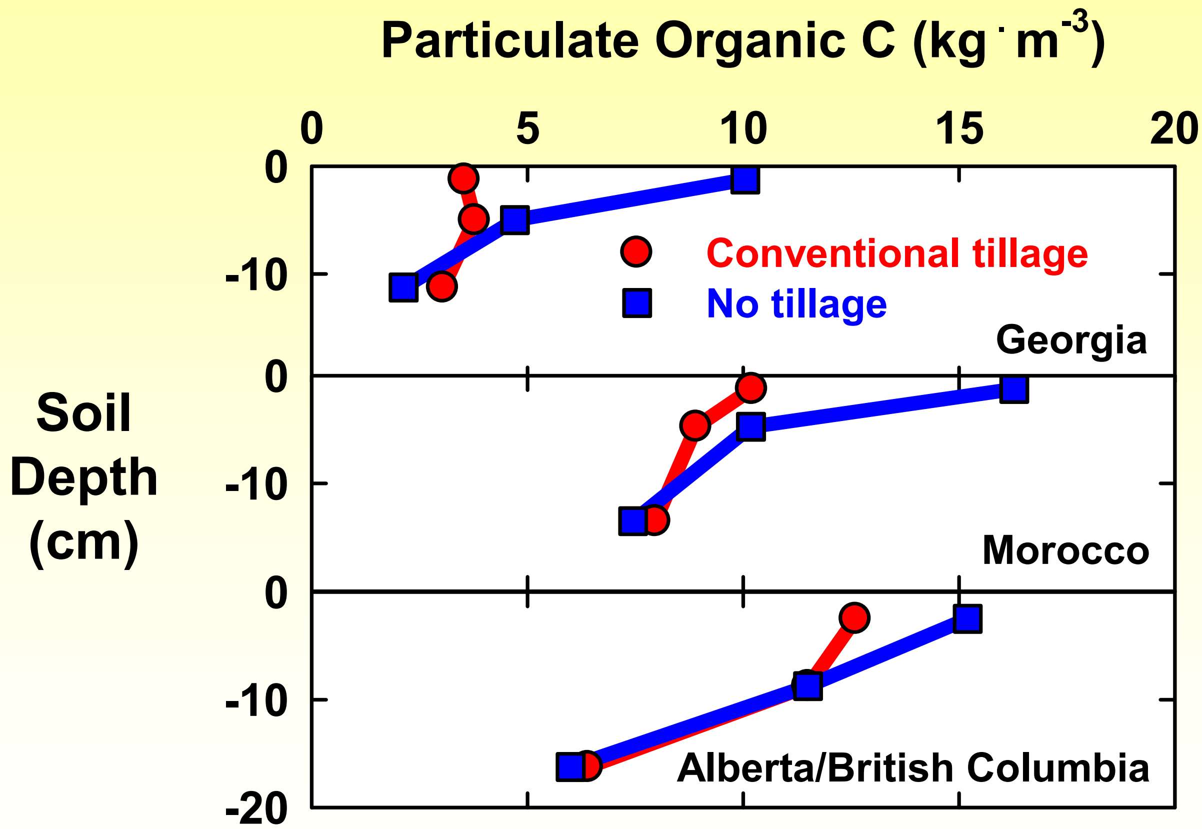
Carbon Content (Mg · ha^{-1})

	DT		NT
	0.1	*	4.3
	3.3	*	5.9
	7.5		7.4
	10.3		8.9
Soil (0-15 cm)	21.1		22.2
Soil + residue	21.2	*	26.5

Data from Franzluebbers et al. (1999) Soil Sci. Soc. Am. J. 63:349-355

Soil Carbon Sequestration

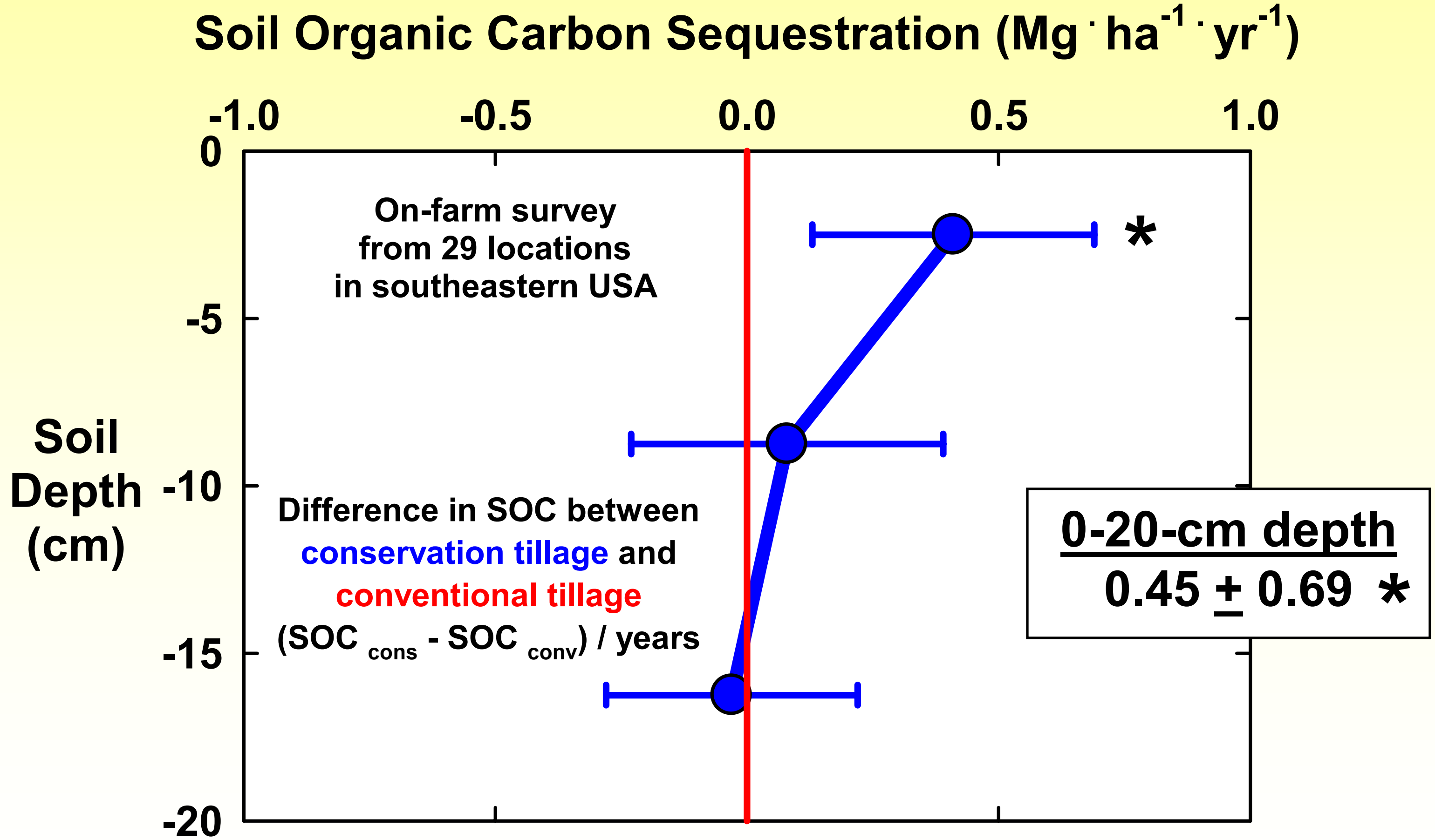
Depth distribution of soil organic C



Data for Georgia from Franzluebbers et al. (1999) Soil Sci. Soc. Am. J. 63:349-355;
for Morocco from Mrabet et al. (2001) Soil Till. Res. 57:225-235;
for Alberta/BC from Franzluebbers and Arshad (1997) Soil Sci. Soc. Am. J. 61:1382-1386)

Soil Carbon Sequestration

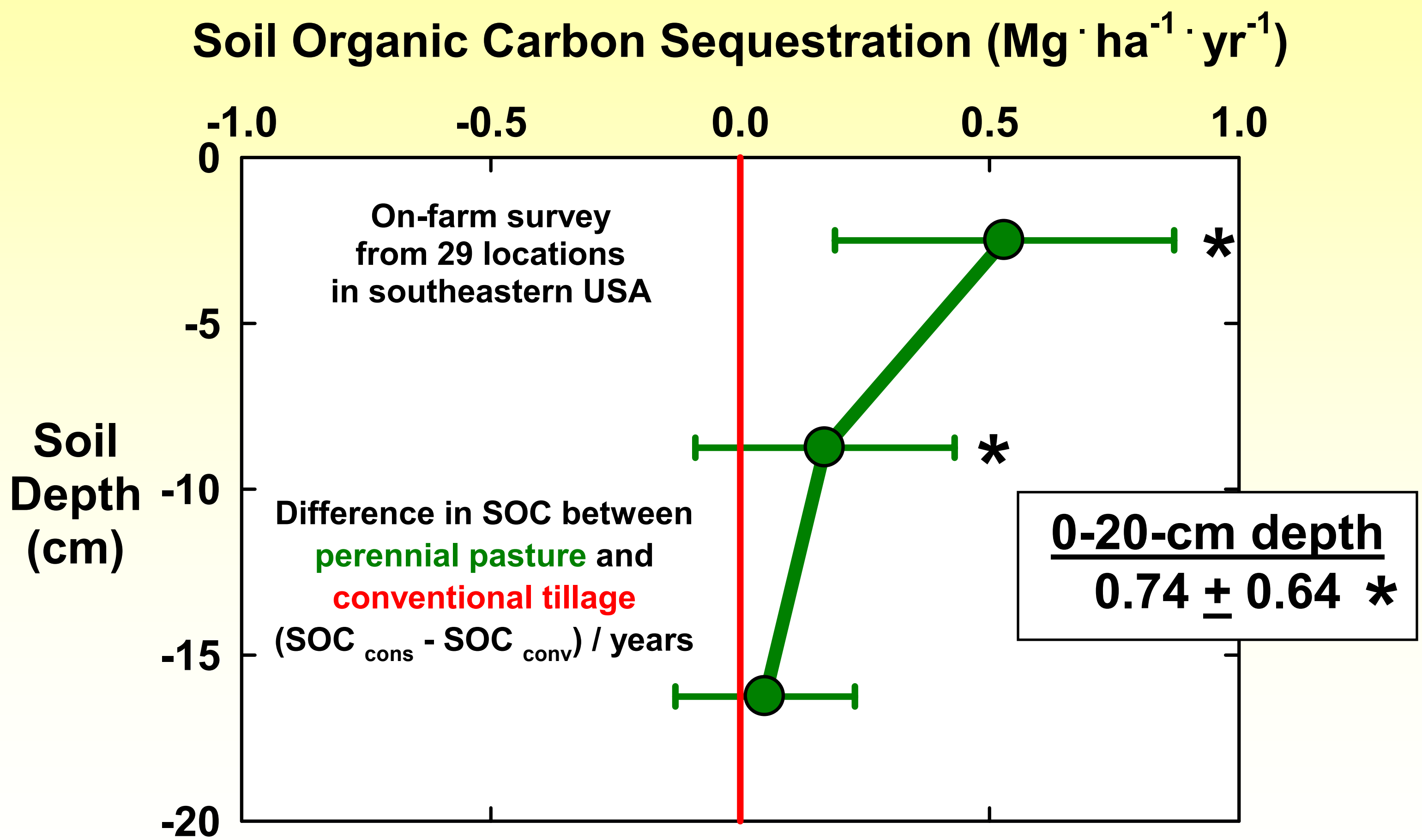
Calculation by relative difference



Data from Causarano et al. (2008) Soil Sci. Soc. Am. J. 72:221-230

Soil Carbon Sequestration

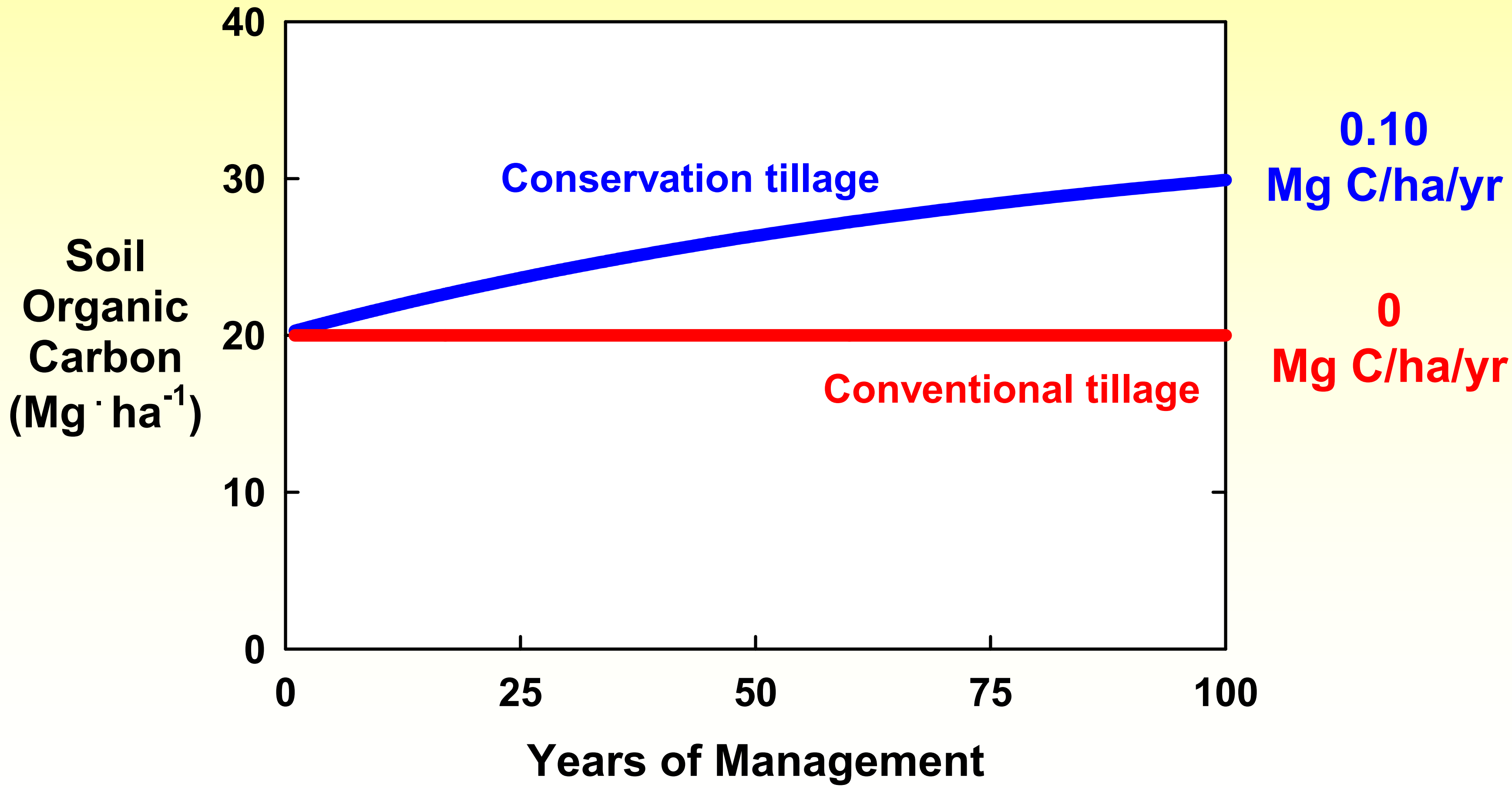
Calculation by relative difference



Data from Causarano et al. (2008) Soil Sci. Soc. Am. J. 72:221-230

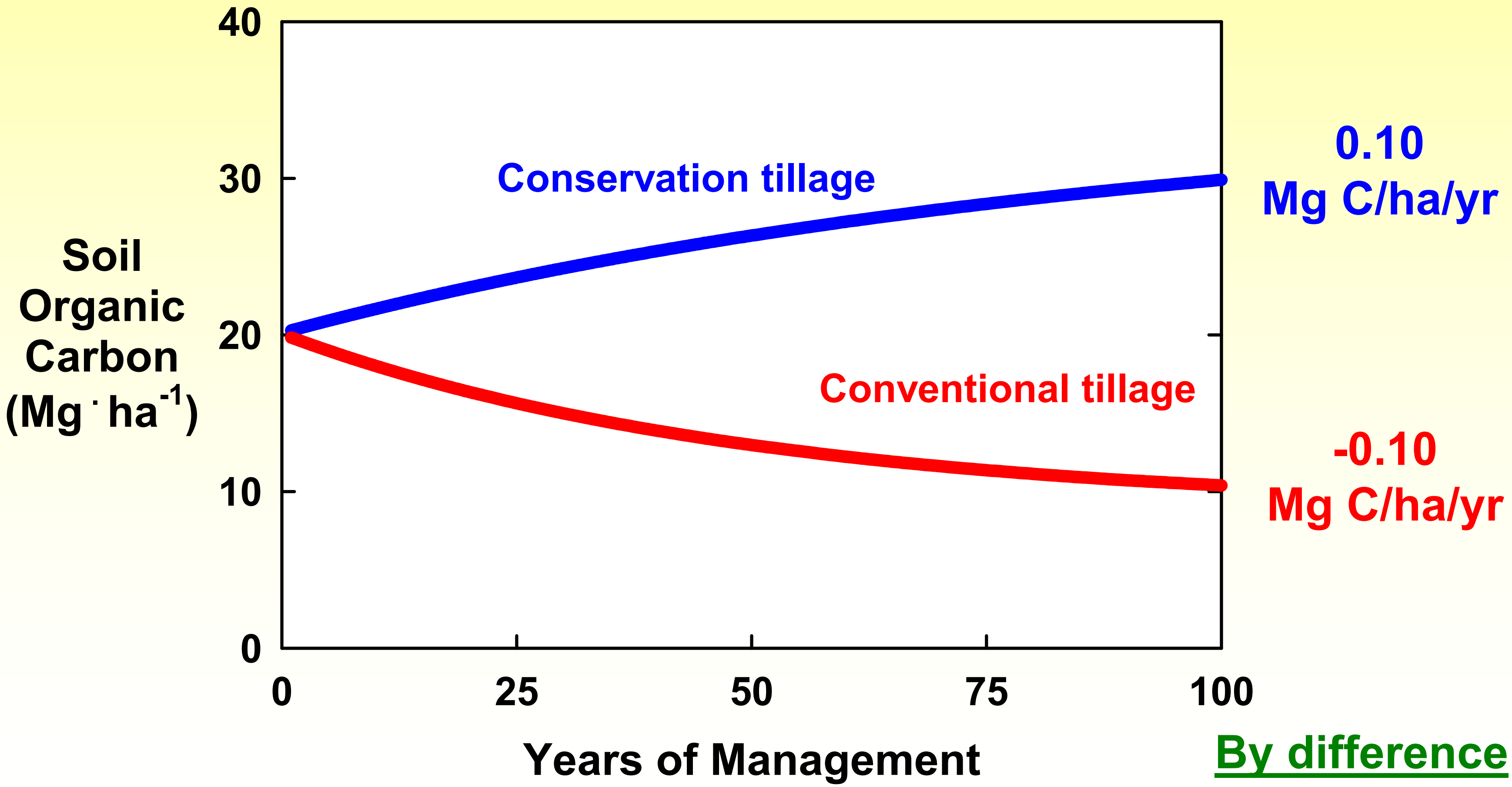
Soil Carbon Sequestration

Calculation by change with time



Soil Carbon Sequestration

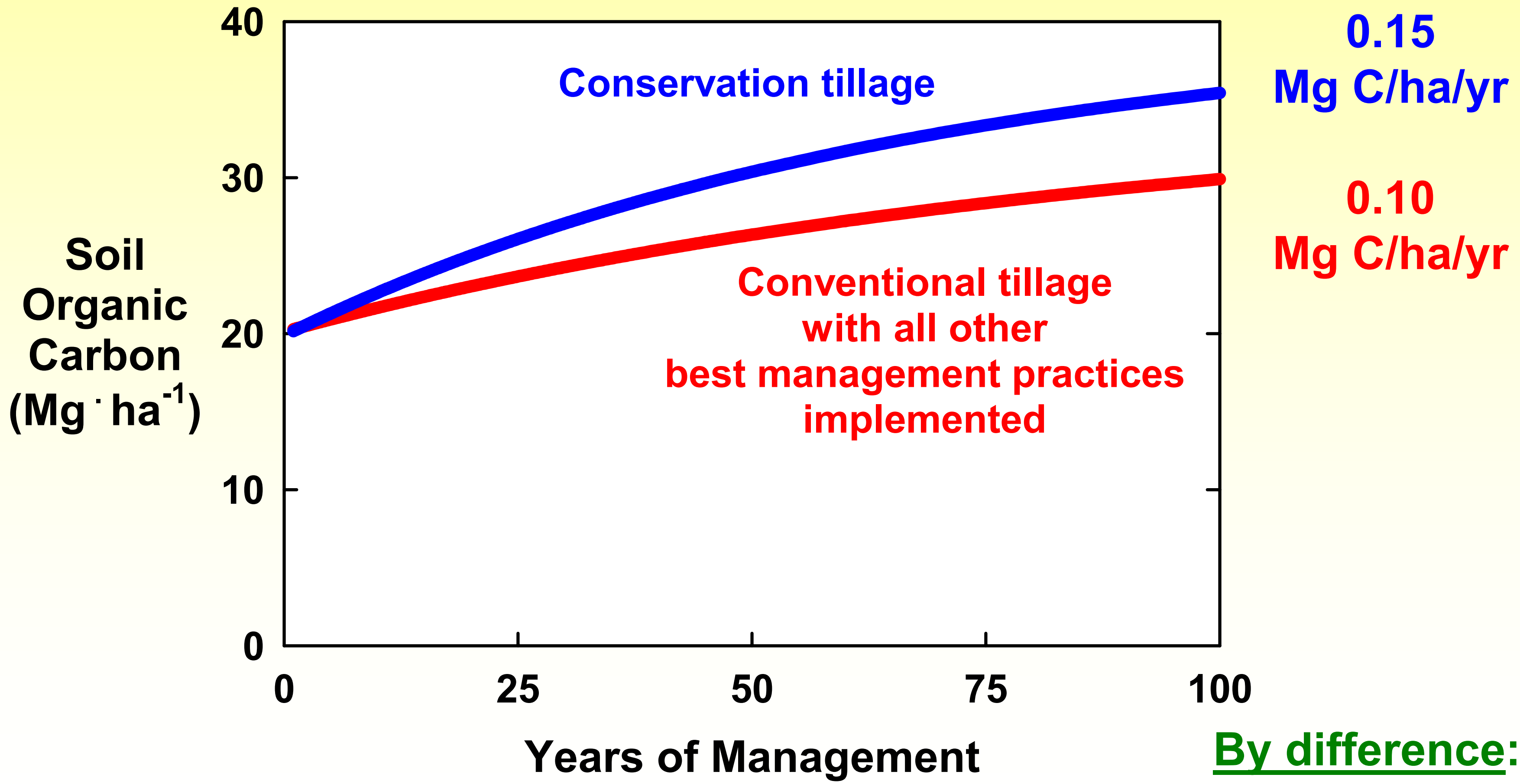
Calculation by change with time



By difference: 0.20 Mg C/ha/yr

Soil Carbon Sequestration

Calculation by change with time

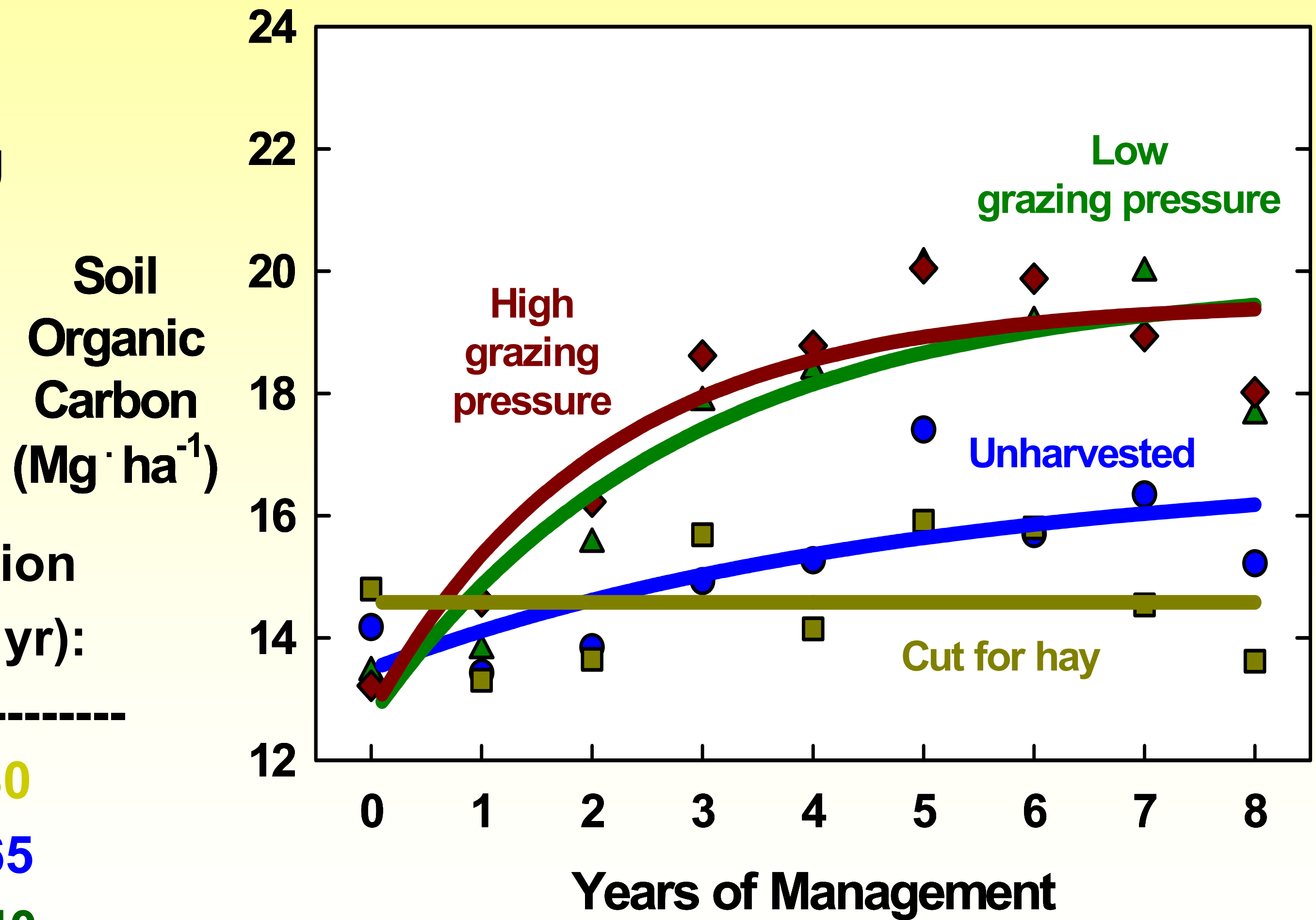


<u>By difference</u>:
0.05 Mg C/ha/yr

Soil Carbon Sequestration

Calculation by change with time

Establishment of bermudagrass pasture following long-term cropping in Georgia USA (16 °C, 1250 mm)



Soil C sequestration

(Mg ha^{-1} yr^{-1}) (0-5 yr):

Hayed	0.30
Unharvested	0.65
Grazed	1.40

Franzluebbers et al. (2001) Soil Sci. Soc. Am. J. 65:834-841 and unpublished data

Soil Carbon Sequestration

Calculation by modeling

Using:

(a) remote sensing (Quickbird, SPOT) of land use from a 64 km^2 area in Mali (750 mm yr^{-1})

(b) EPIC-Century modeling of agroecosystem processes

erosion and soil organic C sequestration were predicted (25 y):

Management (49% cropped)	Erosion ($Mg\ ha^{-1}\ yr^{-1}$)	Soil Organic C ($Mg\ ha^{-1}\ yr^{-1}$)
Conventional tillage (CT)	16.5	−0.023
CT with increased fertilizer	15.0	−0.006
Ridge tillage (RT)	6.6	0.001
RT with increased fertilizer	5.9	0.027
RT with fertilizer and residues	3.5	0.086

Doraiswamy et al. (2007) Agric. Syst. 94:63-74

Soil Carbon Sequestration

Calculation by modeling

Using:

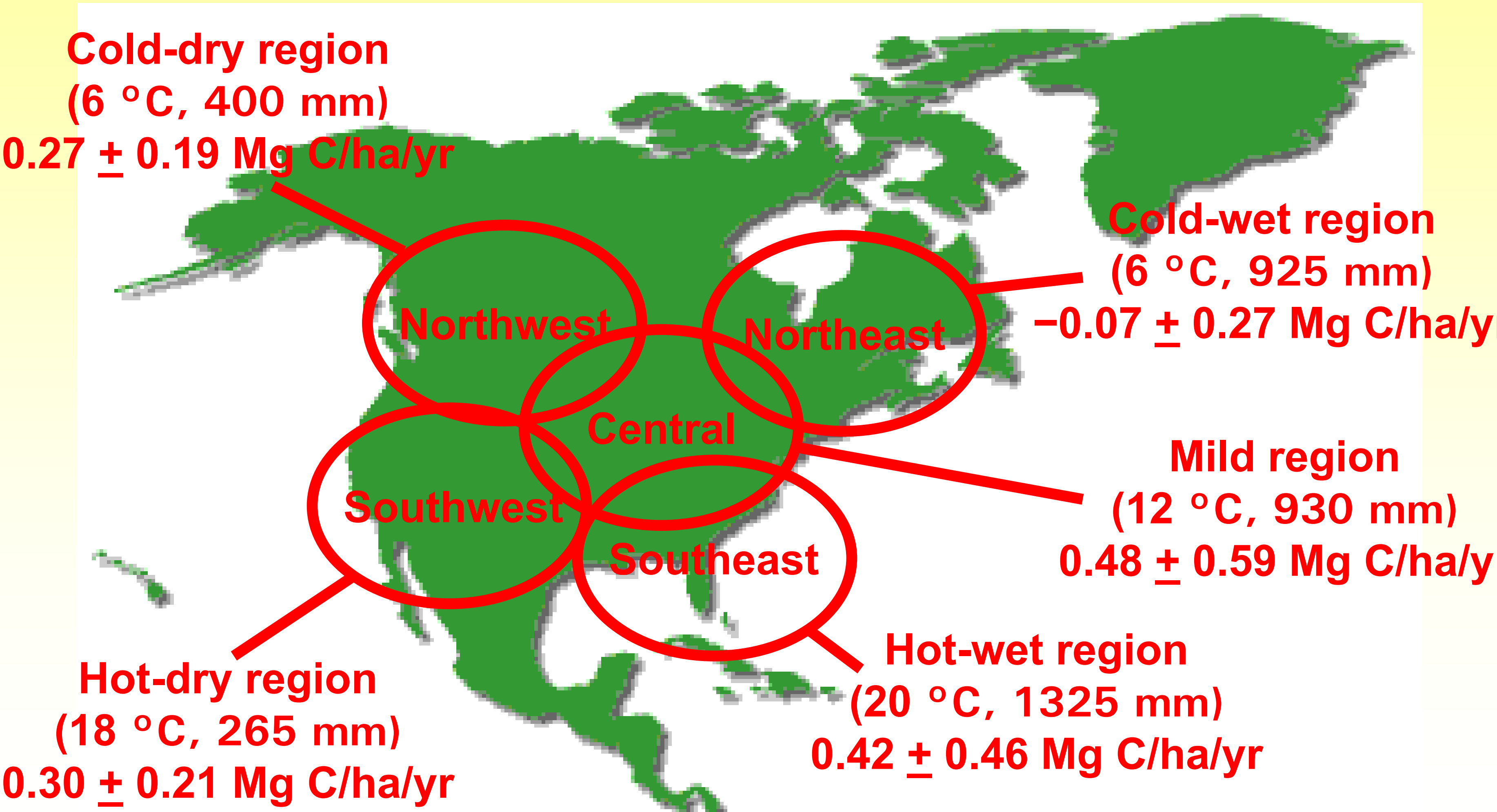
(a) EPIC-Century modeling of cotton production systems:

Management	Lint Yield ($Mg\ ha^{-1}$)	Soil Organic C Sequestration ($Mg\ ha^{-1}\ yr^{-1}$)
Conventional tillage (CT) cotton	1.4	- 0.03 b
No tillage (NT) cotton / wheat	1.2	0.39 a
NT cotton / wheat – corn / wheat	1.3	0.49 a
NT cotton / wheat – corn / wheat – bermudagrass	1.2	0.50 a

Abrahamson et al. (2007) J. Soil Water Conserv. 62:94-102

Soil Carbon Sequestration

In the USA and Canada, conservation-tillage cropping can sequester an average of 0.33 Mg C/ha/yr



Data from Franzluebbers and Follett (2005) Soil Tillage Res. 83:1-8

Soil Carbon Sequestration

- ✓ No tillage needs high-residue producing cropping system to be effective

Photos of 2 no-tillage systems in Virginia USA

Soil Organic Carbon Sequestration in the Southeastern USA

0.28 ± 0.44 Mg C/ha/yr (without cover cropping)

0.53 ± 0.45 Mg C/ha/yr (with cover cropping)

Franzluebbers (2005) Soil Tillage Res. 83:120-147.

Soil Carbon Sequestration

Impact of residue retention on other responses

- ✓ From the 12th year of an irrigated wheat-maize rotation in the volcanic highlands of central Mexico, rate of water infiltration, crop yield, and soil organic C reflected differences in surface soil condition due to residue management:

Tillage	Residues	Infiltration (cm h^{-1})	Yield (Mg ha^{-1}) Maize	1996-2002 Wheat
Zero	Without	18	3.4	3.9
Zero	With	90	4.8	5.4

Retaining residues for 12 years significantly increased soil organic C, but absolute treatment values were not reported.

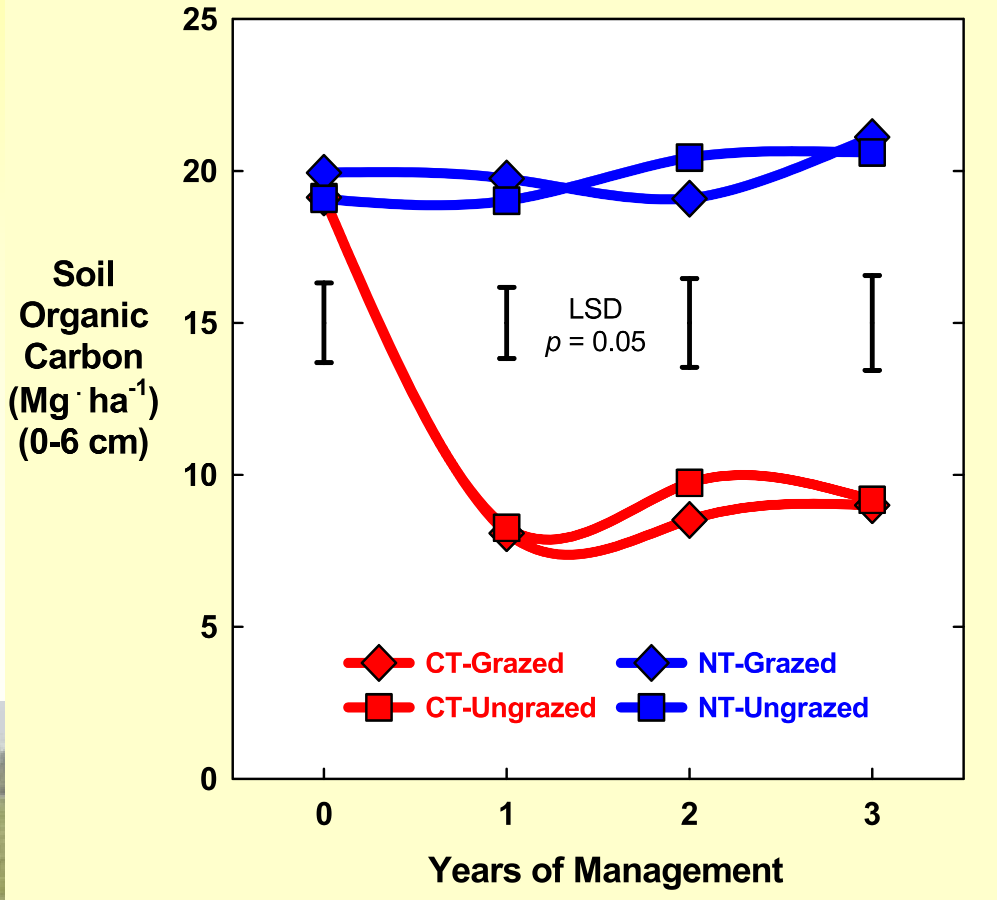
Govaerts et al. (2007) Soil Tillage Res. 94:209-219

Soil Carbon Sequestration

Integration of crops and livestock

✓ **Opportunities exist to capture more carbon from crop and grazing systems when the two systems are integrated:**

- **Utilization of ligno-cellulosic plant materials by ruminants**
- **Manure deposition directly on land**
- **Weeds can be managed with management rather than chemicals**



Franzluebbers and Stuedemann (unpublished)

Soil Carbon Sequestration

Summary

Soil organic carbon can be sequestered with adoption of conservation agricultural practices

- ✓ Enhanced soil fertility and soil quality
- ✓ Mitigation of greenhouse gas emissions
- ✓ Soil surface change is most notable
- ✓ Long-term changes are most scientifically defensible